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*On the Aerolitic Epoch of November 12th-13th.*

BY DANIEL KIRKWOOD.

*(Read before the American Philosophical Society, March 1, 1878).*

It is now well-known that clusters of small meteors—the so-called shooting stars—move in elliptic orbits about the sun. Catalogues of fire-balls and meteoric stones indicate, moreover, that groups of *larger bodies*, somewhat widely dispersed, revolve in like manner about the centre of our system; their orbits in certain cases intersecting that of the earth. The 12th and 13th of November is one of these *aerolitic epochs*; the date being nearly coincident with that of the great November shower of falling stars. The writer until recently supposed the meteorites of this epoch to revolve in the same orbit with the nebulous swarm which furnished the showers of 1833, 1866 and 1867.\* Later study of the facts, however, has rendered the theory of this intimate relation extremely improbable. The principal phenomena of this epoch (not including star showers) are the following:

- (a.) 1582, meteoric phenomena at Zurich.
- (b.) 1765, an extraordinary meteor at Frankfort.
- (c.) { 1820, a detonating meteor seen in Russia.
- (d.) { 1822, fall of aerolites at Potsdam and Leipsig.
- (e.) 1828, a great meteor seen in full sunshine in France.
- (f.) 1835, a fall of aerolites in France.
- (g.) { 1849, a fall of aerolites at Tripoli.
- (h.) { 1849, a large meteor seen in Mecklenberg.
- (i.) 1856, a meteoric stone fell in Italy.
- (j.) 1877, a brilliant meteor seen in Arkansas and another in Wisconsin.

## REMARKS.

(a.) This so-called “fall of fire from heaven” occurred on the 28th of October, O. S., or November 7th, N. S. Making allowance for the precession of the equinoxes, the date corresponds at present to the morning of November 12th.

(b.) This bolide was observed November 11th, and is the only one in our list which occurred *very* near the epoch of the great star shower in November.

(c.) See Greg’s catalogue of fire-balls and meteoric stones; also Quetelet’s catalogue of shooting stars.

(d.) Several aerolites fell at this date near Potsdam, and also at Taucha, near Leipsig, about 75 miles distant.

(e.) See Quetelet’s catalogue.

(f.) This fall of aerolites occurred on the evening of November 13th, in the department de l’Ain, France. The meteor was *unconformable* to the

\* A list of stone-falls, detonating meteors and large fire-balls which have appeared about this epoch is given in *Meteoric Astronomy*, pp. 58-60.

radiant of the Leonids ; its motion being from south-west to north-east. A fragment is in the collection of Prof. Shepard, of Amherst, Massachusetts.

(g.) The meteoric phenomena of this date are thus described in the catalogue of Mr. Greg : "Seen in the southern sky. Varied in color ; a bright cloud visible one and a half hours after ; according to some a detonation heard fifteen minutes after bursting. Seen also like a stream of fire between Tunis and Tripoli, where a shower of stones fell ; some of them in the town of Tripoli itself."

(h.) This fire-ball appeared on the same evening or night.—Greg's catalogue.

(i.) This aerolite fell at Trezano. A fragment is in the collection of Professor Shepard.

(j.) A large meteor was seen by Professor Robert C. Hindley, of Racine, Wisconsin, on Sunday evening, November 11th, at three minutes past six o'clock (Chicago time?). This meteor is thus described by Professor H. in the *Scientific American* for December 1, 1877 : "Direction N. N. E. ; altitude at commencement of course about  $30^{\circ}$  ; length of course from  $10^{\circ}$  to  $12^{\circ}$  ; time of falling about 8 seconds. It fell towards the west, making an angle in falling to the earth of about  $65^{\circ}$  with the vertical passing through the body. During the latter three-fourths of its course, its length, including the luminous trail, was about one-half of a degree. The nucleus was very brilliant ; its color at first a yellowish-white, then a light green, and lastly, a greenish-yellow. Could its color have been due to boron, thallium, &c.? I find no record in any of the numerous analyses of meteoric stones of the presence of elements likely to give the green color."

On the following evening, November 12th, at 6h. 36m. (Memphis time), Frank L. James, Ph. D., M. D., of Osceola, Arkansas, saw another meteor in the same part of the heavens, and in some respects so strikingly resembling that observed in Wisconsin, that he was disposed, on reading Prof. Hindley's description, to think they had observed the same phenomenon, and that one or the other had mistaken the date. I have, however, corresponded with both the gentlemen, and have found that the meteors were seen on different evenings. "The date is fixed," says Dr. James, "not only by my own 'case-record' but by that of a friend and brother physician who assisted me in an amputation on the previous day." The following account of the Arkansas meteor is extracted from Dr. J's communication in the *Scientific American* for December 29th, 1877 : "I was startled by a sudden glare of light which seemed to come from right in front of me. Throwing up my eyes I saw a large and very brilliant meteor in the north-east, falling apparently nearly straight downward, with a slight deviation to the east. When I first saw the meteor it was about  $30^{\circ}$  in height, and judging from the length of time it took to travel the remainder of its course, it must already have fallen  $3^{\circ}$  or  $4^{\circ}$ . It fell through an arc of about  $12^{\circ}$  or  $15^{\circ}$  in all, and was about ten seconds in falling. When I first saw it it had a golden hue which suddenly changed to green, of that peculiar shade produced by burning chlorate of potash with nitrate of barium and

sulphur. The light shed by it was pulsating and sufficiently powerful to light up the Tennessee shore and the sand bars, so as to show every log and stump."

#### PROBABLE INFERENCES.

1. The number of stone-falls and detonating meteors observed on the 11th, 12th, and 13th of November is more than double the average daily fall. Hence the periodic return of a cluster whose orbit intersects that of the earth is rendered highly probable.

2. None of the aerolites or meteors of the preceding list are known to have been conformable to the radiant in Leo, while those of November 13th, 1835 and November 12th, 1877, were certainly *un-conformable*; their heliocentric motion having been direct. This aerolitic group cannot therefore be connected with the shooting stars of November 14th.

3. These facts, it must be confessed, are unfavorable to the hypothesis, formerly advocated by the writer, that "meteoric stones are but the largest masses in the nebulous rings from which showers of shooting stars are derived."\* It is true that in the great star showers of 1799, 1833 and 1866 a number of large fire-balls were seen which belonged undoubtedly to the cluster of Leonids; but it is remarkable that among all this number no detonation was ever heard, and that no meteoric stones have ever fallen during these extraordinary star showers.

4. The dates of the phenomena given above indicate a period of seven years. Several sporadic fire-balls, however, have appeared at this epoch, and no definite conclusion in regard to the period is possible without additional data.

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#### *Criteria of the Nebular Hypothesis.*

BY PLINY EARLE CHASE, LL.D.,

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(*Read before the American Philosophical Society, March 1, 1878.*)

The views of astronomers, respecting the mode of action in world-building, have been various and vague. No one appears to have put upon record any numerical calculations, undertaken with a view crucially to test the nebular hypothesis, or any suggestions as to the proper way to make such calculations.

Statements have been made, at different times, by investigators who thought that observed velocities might be explained by the results of nebular condensation, but no one, except Ennis,† has given us any means of judging on what grounds the belief rested. It seems probable that they all regarded the formation of planetary rings as confined to the superficial

\* *Meteoric Astronomy*, p. 64.

† "Origin of the Stars;" *L., E. & D. Phil. Mag.* April, 1877.